GENERAL RESULTS OF THE WORK IN ATMOSPHERIC ELECTRICITY ABOARD THE CARNEGIE, 1909–1914.

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Notable progress, it is believed, has been achieved by the department of terrestrial magnetism of the Carnegie Institution of Washington during the past year in the perfection of the instrumental appliances for observations in atmospheric electricity. In various articles by Drs. Swann and Hewlett, which have appeared in the *Journal of Terrestrial Magnetism and Atmospheric Electricity,* 1913–1914, new points of theory were brought out, serious errors in certain instruments were made known, and improved methods and instruments were devised. As a result considerable improvement has been made in the work in atmospheric electricity aboard the *Carnegie,* especially on her present cruise.

It is now deemed worth while to expand the work of the department in atmospheric electricity in two directions: (*a*) Continuous observations, by self-recording means, at the department's laboratory in Washington and at such observatories elsewhere as the department may be able to establish in the near future. (*b*) A general electric survey of the globe, implying observations at points distributed over the earth's surface, somewhat as in a magnetic survey.

Probably the late Professor Rowland was one of the first, in his address before the Congress of Electricians, held at Paris, September, 1881, to point out the need in atmospheric electricity "of a series of general and accurate experiments performed simultaneously on a portion of the earth's surface as extended as possible."[1] He says that "the principal aim of scientific investigation is to be able to understand more completely the laws of nature, and we generally succeed in doing this by bringing together observation and theory."

[1] Physical Papers of Henry A. Rowland, Baltimore, 1902, p. 212 et seq.

On Professor Rowland's motion the Congress resolved "that an international commission be charged with determining the precise methods of observation for atmospheric electricity, in order to generalize this study on the surface of the globe."

Unfortunately, in the past, the observations in atmospheric electricity have often been found to be counterfeits of nature because of the errors inherent in the instruments and methods used. Accordingly the much-desired discovery of nature's laws by "bringing together observation and theory" has not been effected in the measure desired. None of the proposals for a general electric survey of the earth which have been made repeatedly to learned academies, one of the last having been presented to the International Association of Academies, has been put into effect, doubtless because of the discouraging experiences encountered.

In spite of the vast work already done by notable investigators, we still have no generally accepted theory of the origin of atmospheric electricity.

Probably one of the most important of recent contributions to the observational data is the series of observations obtained on the past cruises of the *Galilee* and the *Carnegie*. A report giving the results up to the end of 1913, obtained by the department observers and others, was prepared by Dr. Hewlett and published in the September, 1914, issue of *Terrestrial Magnetism and Atmospheric Electricity*. The observations comprised, in addition to the usual meteorological measurements, those of the potential gradient, atmospheric conductivity and radioactive content of the atmosphere. Perhaps the most important result was a confirmation of the somewhat striking phenomenon, that while the conductivity over the ocean is, on the average, at least as great as over land, the radioactive content is much smaller. The values of the potential gradient obtained at sea were of the same order of magnitude as those on land.

Dr. Swann has just completed a report on the atmospheric-electric observations taken during the third cruise of the *Carnegie* while under the command of Mr. J. T. Ault, in 1914. The general course of the *Carnegie* during this cruise was as follows: Leaving Brooklyn on June 8, 1914, she arrived at Hammerfest on July 3.

Sailing again from Hammerfest on July 25 she entered the harbor of Reykjavik, Iceland, on August 24, having reached the latitude of 79° 52′ North, off the northwest coast of Spitzbergen. Leaving Reykjavik on September 15, the *Carnegie* arrived at Greenport, Long Island, on October 12, returning to Brooklyn on October 21, 1914.

The observations in 1914, comprised, in addition to the magnetic and meterological data, measurements of the potential-gradient, the conductivities for the positive and negative ions, and the radioactive content. Measurements of the ionic numbers were also made during the passage from Greenport, through Long Island Sound to New York. The whole of the observations, with the exception of a few measurements in Long Island Sound by Dr. Swann, were taken by Observer H. F. Johnston.

The average values of the potential-gradient, atmospheric conductivity, and radioactive content for the whole cruise were, respectively, 93 volts per meter, 2.52×10^{-4} E. S. U., and 23, the last number being expressed in Elster and Geitel units. The average value of the earth-air current for the whole cruise was 7.7×10^{-7} E. S. U. per sq. cm.

The atmospheric-electric elements were measured daily between the hours of 9 A. M. and 12 noon. The observations as far as they go indicate a general increase of the potential-gradient from summer to winter, which is in accord with land observations for the daily mean values. The conductivity also shows a general increase from the beginning of the cruise (June 8, 1914) to about the end of September, when a maximum occurs, after which the conductivity falls.

No marked variation of the atmospheric-electric elements with temperature or humidity was found. However, an indication is shown of a variation of the conductivity with latitude; a maximum for the latitudes involved occurring in the neighborhood of 50° North. These conclusions with regard to the variation of the elements with season, latitude, etc., must be looked upon as tentative owing to the small number of data involved.

The conductivity appears to have an especially low value in the neighborhood of the American coast. In Long Island Sound,

measurements were made of the ionic numbers n_+ and n_-, and the results indicate that the low values of the conductivity referred to above are to be attributed partly to a low value of the specific velocities of the ions (v_+ and v_-). The mean values of v_+ and v_- for observations on three days in Long Island Sound are respectively 0.77 and 0.83 cm./sec. per volt per cm. The average value of n_+ and n_- for observations taken on three days in Long Island Sound are 340 and 280 ions per c.c. respectively.

By making use of the value (23) given above for the radioactive content, and of the empirical relation obtained by Kurz, for the reduction of the Elster and Geitel unit to absolute value, it turns out that the average radioactive content for the whole cruise amounts to about 12 curies of radium emanation per cubic meter as against 80 curies per cubic meter which is about the average value found over land. The emanation content is thus too small to account for the conductivity observed over the sea, which conductivity is as great or greater than that measured over land.

A criticism of the ordinary method of drawing conclusions as to the nature of the radioactive products in the atmosphere, by comparing the decay curve with one obtained by a wire exposed in a closed vessel, is given in Dr. Swann's report. The activity curves are analyzed in the report mathematically, use being made of the theory of radioactive disintegration, and it is found that while some of the curves can be explained by radium emanation alone, others require the presence of a product of longer decay period than radium *A, B* or *C*. The possibility of this extra product being a product of thorium emanation, as is generally assumed to be the case on land, is discussed by Dr. Swann.

An attempt to calculate the actual amount of radium emanation in the air directly from the theory of the Elster and Geitel method, without assuming any empirical relation results in a much smaller value for the radium-emanation content than that given by the empirical relation unless it is assumed that the average specific velocities of the active carriers are much smaller than is generally supposed.

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